RICE INTENSIFICATION

This past year there has been a considerable expansion in knowledge and usage of the System of Rice Intensification (SRI). This methodology was developed in Madagascar in the 1980s by Fr. Henri de Laulanié, S.J., and is being promoted by Association Tefy Saina, a Malagasy NGO with which CIIFAD has been working since 1994. When SRI was featured on the cover of the *CIIFAD AnnualReport 1996-97*, the method was not known outside of Madagascar.

The rapid spread of interest is due mostly to the fact that this methodology increases rice yields dramatically without requiring the purchase of new seeds, chemical fertilizers or other inputs, and also partly due to the speed and cheapness of modern electronic communication. On the Internet, inquiries, reports and technical papers can be transmitted around the world in a matter of seconds practically free.

Even with such facilities, though, we cannot know all the places where SRI trials are being conducted, or have complete up-to-date information. The first trials outside of Madagascar began in China and Indonesia in 1999, facilitated by CIIFAD. Now two years later, we are in communication with researchers, NGOs or farmers in two dozen countries who are evaluating SRI methods and principles or planning to evaluate them.

In October 2000, Norman Uphoff was invited to give a paper on SRI at a conference on "Raising Agricultural Productivity in the Tropics" at the Center for International Development at Harvard University. In January 2001, Sebastien Rafaralahy, president of Association Tefy Saina, made a presentation on SRI at a conference in London on "Reducing Poverty through Sustainable Development." This event, sponsored by the British Department for International Development and the University of Essex, was held in St. James Palace, with Prince Charles hosting the participants. There were follow-up reports on SRI on the BBC World Service and in the *Financial Times* (January 24, 2001) and *New Scientist* (February 3, 2001).

An agricultural-support NGO based in Florida published a description of SRI methods in its newsletter, *ECHO Development Notes*, in January 2001. ECHO's mailing list reaches 3,000 readers in 140 countries. The Intermediate Technology Development Group in London also prepared a feature on SRI for its magazine *Appropriate Technology*. Information is thus starting to flow through many channels, and CIIFAD gets queries or reports from individuals and organizations starting to work with SRI several times a week.

The most interesting communication came in January 2001, a handwritten letter from a farmer in the Indian Punjab (see next page). Based on the brief description of SRI he read in our 1998-99 annual report, he tried these methods and was very pleased with the results. He should get still higher yields once he understands the system better. After briefly describing SRI below, we review reports coming in from around the world.

System of Rice Intensification

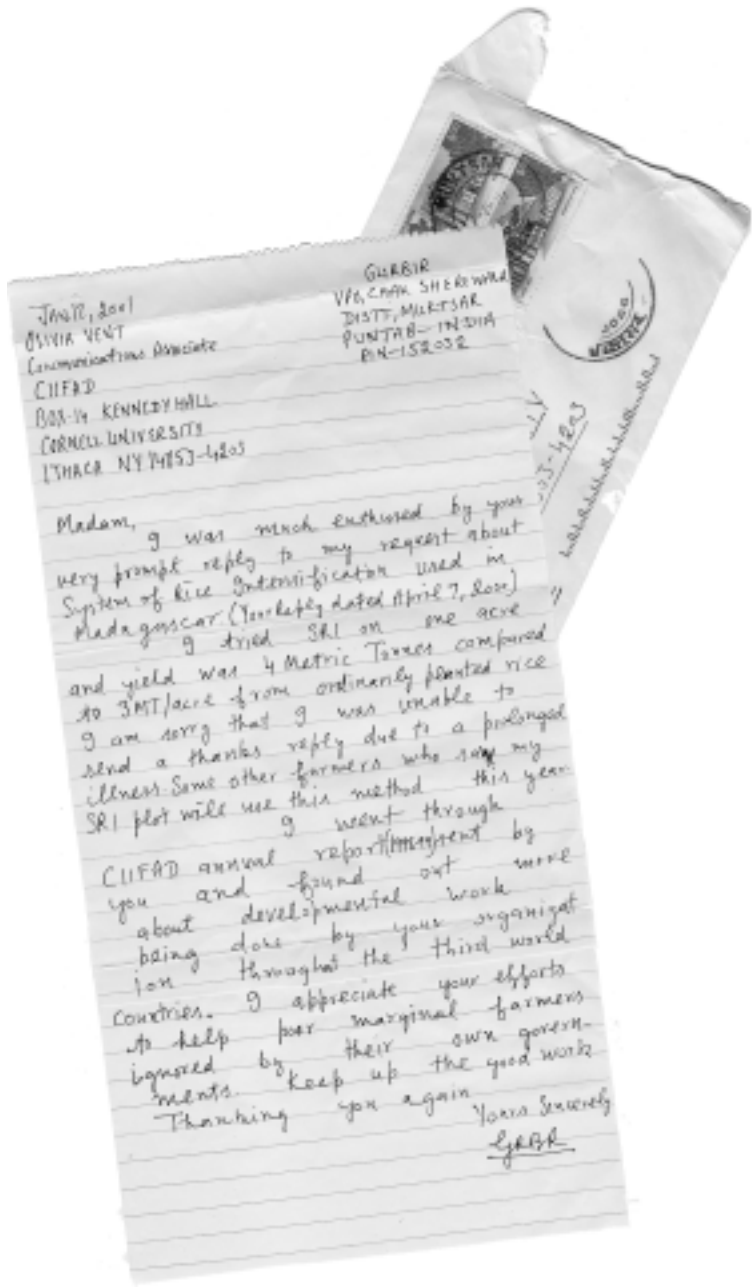
This system for raising rice yields is not viewed by Tefy Saina or CIIFAD as a technology, with a fixed set of practices that farmers are expected to adopt. Rather it is a methodology that applies certain principles and insights about how rice plants can be assisted to perform better. It improves their growing environment by introducing different practices for managing plant, soil, water, nutrient and microbial interactions.

While certain techniques are recommended for SRI, farmers are encouraged to experiment with these, to adapt them to local conditions, satisfying themselves that these are beneficial. Fr. de Laulanié was more concerned ultimately with human resource development than with rice production, and he regarded SRI as a means to further the former, not just grow rice.

The system can be summarized in terms of six main elements, some of them changing things that farmers have done with irrigated rice for many centuries.

- Seedlings are transplanted when they are *very young*, 8-15 days old, when they have just two leaves. This maintains greater plant potential for extensive tillering and root growth than older seedlings have. Seedlings are raised in a garden-like rather than in a flooded nursery.
- Seedlings are *widely spaced*, only one per hill rather than in clumps of three or four plants, and in a square pattern at least 25 by 25 cm apart, and wider if soil conditions are good. This gives rice roots and canopies more room to grow and to express genetic potential that they already possess but which is inhibited to the most common cultivation practices.
- Seedlings are also transplanted *very carefully*, getting seedlings quickly and gently from the nursery into the field, and placing the tiny roots in a position so that they can quickly resume their downward growth. This avoids the 7 to 14 day setback in growth common with usual transplanting methods. More time can be taken in handling SRI seedlings because many fewer of them are transplanted. Seeding rates are 5-10 kg/ha instead of rates usually 10 times higher.
- *Water is carefully managed* during the vegetative growth stage, up to the time of panicle initiation. The paddy field is not kept flooded, as is usual practice. Instead, the soil is kept moist and well-drained, or intermittently flooded and dried if this is appropriate for soil conditions and can save labor.

The goal of water management is not just to furnish water to the plants' roots but to avoid hypoxic conditions that force the plant to sacri-



GAMINI BATUWITAGE

SRI practices can be applied to both traditional and high-yielding rice varieties. A high-yielding variety developed by Sri Lankan researchers, BG-358, yielded 17 tons per hectare in trials during 2001.

fice a large part of its roots to form air pockets that help keep the root alive. In continuously saturated soils, most of the irrigated rice roots die by the start of the reproductive stage. From this stage, for SRI just a thin layer of water is kept standing on the field. Only half to one-third as much water is used in total as with continuous flooding.

- Without flooding, weeds can become a problem. Thus with SRI it is recommended to begin *weeding* about 10 days after transplanting and to do two to four weedings at 10-15 day intervals. Using a simple mechanical push-weeder designed by the International Rice Research Institute (IRRI) in the 1960s permits aeration of the soil as well as elimination of weeds.
- While SRI was originally developed with chemical fertilizer, this is beyond the reach of most farmers in Madagascar, so *application of compost* is recommended. Our evaluations show that for most varieties, compost gives higher yields than does fertilizer. Many farmers have modified the method so that they apply compost to their inter-season crop (potatoes, beans or some other crop) rather than to their rice, and get better results from both crops. This practice enhances the size and diversity of microbial populations.

These methods have been found to increase the yield from practically all rice varieties that have been used, sometimes doubling or tripling yield, or more. However, it should be noted that the highest yields have come from varieties that have been improved through plant breeding. High-yielding varieties offer some advantages with SRI.

In August 2001, staff from the Sri Lankan government's department of Census and Statistics were asked to do crop-cuts on some SRI plots to ensure that the measurement was done according to standard methods (Gamini Batuwitage, Additional Secretary, Ministry of Lands, e-mail communication, September 12, 2001).

- The yield from a traditional variety, *Rathhel*, was calculated as 9.3 tons per hectare (t/ha).
- That from another common variety, *Pachchei-perumal*, was 13.3 t/ha.
- A high-yielding variety developed by Sri Lankan researchers, BG-358, yielded 17.0 t/ha.

For comparison, the world average rice yield is currently 3.6 t/ha. Yield increases in themselves are not so important, because the world does not need a doubling in its production of rice. Rather it is the *increased factor productivity* of land, labor, water and capital with these methods that is important. This can enable even smallholders to meet their staple food needs and also utilize some of their resources for other, higher-valued production.

SRI Field Reports

Asia

Over 90 percent of the world's rice is grown and consumed in Asia, so it is not surprising that interest in SRI has been greatest there.

China

Faculty at Nanjing Agricultural University in China did the first trials with SRI methods outside of Madagascar. The yields obtained in these trials in 1999, with three different spacings, ranged from 9.2 to 10.5 tons per hectare (t/ha). That these could be obtained with about half as much water as usually used was perhaps of more interest than the yield level given China's growing scarcity of water for agricultural purposes.

In April 2001, Nanjing Agricultural University hosted a planning workshop for a collaborative research project organized by faculty at Wageningen University in the Netherlands, with funding from the Dutch government. The project aims to assess potentials for growing rice with less water. CIIFAD assisted in formulating the research project, and Uphoff attended the meeting together with Robert Randiamiharisoa, director of research for the Faculty of Agriculture in the University of Antananarivo in Madagascar, one of the partners in the collaborative effort. This four-year effort is being joined also by researchers from the Agency for Agricultural Research and Development (AARD) in Indonesia and the Tamil Nadu Agricultural University in India.

Professor L. P. Yuan, director of the Chinese National Hybrid Rice Research and Development Center, learned about SRI methods after a rice symposium held at Cornell in June 2000 in honor of the first director-general of International Rice Research Institute (IRRI), Robert Chandler. The hybrid rice varieties that Yuan has developed over the past 25 years have added considerably to the rice production in China. In February 2001, he received the State Supreme Science and Technology Award, China's equivalent to the Nobel prize, for his pioneering rice breeding work. His varieties hold the official record for highest yields in the world, although several farmers in Madagascar have gotten even higher yields with SRI methods.

Based on his trials with SRI methods, Professor Yuan is satisfied that they can add to the yields from the hybrid varieties that he and his researchers have developed. In April 2001, Yuan invited Randriamiharisoa and Uphoff to visit his southern research center at Sanya on Hainan Island to give a seminar on SRI and see his experimental plots with these methods. Then in August 2001, Uphoff was able to visit his main research center at Changsha in central China, to give another seminar to staff and observe trials on-station there. In both places, trials had yields ranging from 12 to 15 t/ha. The center is testing a number of variations in SRI practices to see which perform best under Chinese conditions.

COURTESY L. P. YUAN

Professor L. P. Yuan (right), director of the Chinese National Hybrid Rice Research and Development Center, shows rice plots to visitors, from left, Robert Randriamiharisoa, University of Antananarivo; Fang Ming Xie, RiceTech, USA; and Norman Uphoff, CIIFAD, at the Sanya research station in China.

Members of the agronomy department at China Agricultural University in Beijing also initiated SRI trials. Trials are also being undertaken at Fujian Agricultural and Forestry University and Guizhou Provincial Rice Institute.

Indonesia

The Agency for Agricultural Research and Development was the second institution to experiment with SRI methods, getting 6.3-6.8 t/ha at its research center at Sukamandi in the 1999 dry season, and then 9.5 t/ha in the wet season in 1999-2000. Farmers using SRI on their fields in this year's wet season produced 7.3 to 8.5 t/ha, about double the national average.

As noted above, AARD is cooperating in the Wageningen-sponsored collaborative project. This past year, its researchers integrated SRI methods into AARD's integrated crop management strategy that is being elaborated and tested in eight provinces across Indonesia. It is expected that this will, with appropriate modifications for local conditions, become a national program to meet the country's rice production needs. Yield levels have been stagnant in Indonesia since the mid-1990s, so researchers and policymakers are urgently seeking means to restore the earlier growth momentum seen during the Green Revolution decades of the 1970s and 1980s.

NORMAN UPHOFF

Farmers working with CARE/Bangladesh staff show the tillering of SRI-grown plants in a farmer's field in the Kishoreganj district. Farmers using SRI methods reported both yield increases and fewer insects per plant.

One of the most successful parts of Indonesia's agricultural development over the past decade has been the integrated pest management (IPM) program (*CIIFAD Annual Report 1994-95*, pp. 28-29). Farmers in Ciamis district learned about SRI from the FAO community IPM program in 2000 and decided to evaluate it for themselves this year.

The report prepared by the Ciamis IPM program commented: "In the beginning, farmers in [the area] surrounding the study plots laughed at them, and they [the experimenters] were not sure about the method because until four weeks after transplanting, they [still] didn't get more tillers. But from the flowering till harvest stage, they [the other farmers] were wondered with the great progress of growing." Pests were also less with SRI practices: < 3 percent per hill, compared with < 8 percent on farmers' fields. The experimenters are encouraging other farmers to evaluate SRI for themselves. The report concluded: "Thank you very much for the discoverer of SRI!"[1]

[1] Enceng Asikin and Koeswara, "Development of SRI (System of Rice Intensification), KSP [Farmer's Science Group], Tirtabumi, Cikoneng, Ciamis District, West Java," IPM Program, Ciamis, June 25, 2001.

BANGLADESH

This country is another major producer and consumer of rice. The paper on SRI presented to our Bellagio conference in April 1999 was taken back to Bangladesh by the participant from CARE/Bangladesh and distributed within that NGO and sent to others concerned with rice. A researcher at the Comilla station of the Bangladesh Rice Research Institute (BRRI), Mian Sayeed Hassan, tried SRI methods on-station and was pleased to get one ton more yield per hectare with the same variety and growing conditions. Since rice yields have been stagnant in Bangladesh for about five years, this was considered a substantial and welcome gain.

When Uphoff visited Bangladesh in December 2000, he met Hassan and other researchers now evaluating SRI at BRRI's main station at Ghazipur, where he gave a seminar on SRI to about 65 research personnel. CARE/Bangladesh staff took him to Kishoreganj district, where they have been working with farmers in farmer field schools for IPM modeled after those established in Indonesia. Since these farmers are accustomed to trying new methods and evaluating them, the schools with their farmers Participatory Action Research Groups are ideal venues for SRI trials.

The 18 farmers who used SRI methods during the 2000 boro season averaged 6.5 t/ha, compared to 5.0 t/ha with present practices on adjacent fields, already about double the current national average yield. Among other things, they found the beneficial:harmful insect ratio to be 5:3 on SRI plots during the vegetative growth period compared to 5:4 on their regular plots. The conclusion of the seasonal report was: "The experience of that new technology of SRI has just opened up a light of hope to the poor farmers to boost up the rice production and to be self reliant in cereal food."[2]

This report also gave detailed data from 53 farmers who had tried SRI methods concurrently under the auspices of the government's Department of Agricultural Extension, which had also gotten the Bellagio paper. Those farmers averaged

[2] Murad bin Azia and Rakibul Hasan, "Evaluation of System of Rice Intensification (SRI) in Bangladesh," CARE-Bangladesh, Dhaka, 2000.

7.5 t/h, with three obtaining yields over 9 t/ha. During the December visit, Uphoff also gave a seminar on SRI to the agricultural staff of the Bangladesh Rural Advancement Committee (BRAC), the largest and most effective NGO in that country.

BRAC undertook a 10-acre trial in early 2001, comparing it with 14 acres under the normal method, and got a 44 percent higher yield. "Though costs [of production] were higher, the higher yields more than compensated, and relative profitability of SRI was found to be better" (e-mail from Muazzam Hussain, BRAC research specialist, July 15, 2001). BRAC is planning to expand SRI trials with farmers in the next season. There are also trials underway in neighboring Nepal and India this year.

Sri Lanka

Farmers in this country began experimenting with SRI following a visit in January 2000 by Joeli Barison, currently doing a master's degree in agronomy at Cornell after doing research for CIIFAD on SRI in Madagascar (*CIIFAD Annual Report 1997-98*, page 59; *CIIFAD Annual Report 1998-99*, page 103). Unfortunately, government researchers have taken a negative attitude toward SRI, objecting that the reported yields are beyond the biological maximum for rice, a concept that is itself disputable.

During 2000-2001, about 300 farmers used the methods, with yields averaging about 8 t/ha. A group of farmers at Namal Oya did some measurements and calculations comparing their observed SRI performance with that of alternative cultivation methods. With their usual practices, the yield was 2.9 t/ha; with the government recommended package of practices, utilizing new varieties and fertilizer, 4.7 t/ha, and with SRI, 8.5 t/ha.[3] The average depth of rooting they measured as 2, 3 and 9 inches, respectively.

Most important, the costs of production per kilogram of rice were calculated to be 6.00, 5.65, and 3.00 rupees, respectively, which makes SRI very attractive even if more labor must be invested. SRI lowered out-of-pocket cash costs per hectare compared with current practice, and cost 30 percent less than the officially recommended package of practices. Even if these numbers are not as exact as researchers might calculate, these represented the differences that farmers saw and experienced.

GAMINI BATUWITAGE

H. M. Premaratna (standing, far left) is a farmer who is so enthusiastic about SRI that he trains farmers every weekend at his farm. A retired engineer recently donated the use of his house to serve as a training center.

Some farmers have become quite enthusiastic about SRI and are promoting it among fellow farmers. H. M. Premaratna, who was shown in the Highlights in last year's annual report, has begun training other farmers at the Nature Farming Center he has set up on his small farm near Mallawalana (see box next page). As his yields with SRI methods have been in the 8-15 t/ha range, Premaratna is fully persuaded of their merits and can speak from personal experience.

An interesting development is that some of the Buddhist clergy are endorsing SRI because it does not require use of chemical biocides. Environmental contamination and health hazards from agrochemicals are becoming a major issue in Sri Lanka, where their use has been subsidized and actively promoted for more than three decades.

Southeast Asia

The Center for Study and Development of Cambodian Agriculture (with the French acronym CEDAC) has been working with farmers in ***Cambodia*** to evaluate SRI for four seasons now. The 28 farmers in four different provinces who used these methods during the 2000 wet season averaged 5

[3] These data were reported by Gamini Batuwitage, Ministry of Lands, at a seminar in Colombo, March 2001. Three farmers also made presentations on their favorable results with SRI.

Farmers Extend SRI in Sri Lanka

E-mail from Gamini Batuwitage, Additional Secretary (Development), Ministry of Lands, Government of Sri Lanka, September 17, 2001:

More than 2,000 farmers have already got training at Premaratna's farm. Every weekend there are 30 to 40 and sometimes 70 farmers who receive training there. Usually farmers from remote areas come in groups in hired vehicles, sometimes with meals prepared. They arrive Saturday evening, have a little rest, have a bath in the village pond, etc., and start sessions in the night. Dinner is served and discussions go up to late at night with video shows, etc. Sunday morning is for practical work such as preparation of the nursery, transplanting, compost making, etc. Important lessons are given including activities for increased biodiversity, improving drainage for water management, etc.

For farmer groups supported by NGOs, there is a special arrangement. They fill out a form requesting what training services are needed, with a cost estimate. Once the cost is paid, training is conducted for these farmers at Mellawalana. High-quality seed including traditional varieties and sun hemp (a green manure rich in N and P) and hand weeders are available for purchase. Our plan is to have 600 leading farmers in 17 districts who have practiced SRI and gotten good results and who are convinced about it, trained in this way to be ready to tell others about the methods. This is farmer-to-farmer expansion emphasizing principles, results and participation, not something imposed upon farmers.

t/ha, more than double their usual yield of 2 t/ha. "The flooding in 2000 was the worst flooding in 40 years," according to CEDAC. "Despite this, there was good performance with SRI in most places." [4] In the dry season, yields with SRI averaged 6 t/ha, with a few farmers getting as much as 13 t/ha.

As in the Ciamis, Indonesia, report, there was initial reluctance to experiment with SRI. "They [other farmers] did not believe that they could produce more than 4 or 5 tons of rice per ha without using special seeds, fertilizer, and having a good water supply… However, after exposing them to the fields where a few farmers had started to grow SRI, they were more satisfied. Thus, during the season, more and more farmers decided to test SRI." This current season, about 300 farmers are using SRI methods, with Catholic Relief Services also supporting testing and extension of the system.

The Consortium for Development of Southern Mindanao Cooperatives (CDSMC) continues its work with farmers evaluating SRI in the ***Philippines***. Faculty and students in the Agronomy department of the University of the Philippines at Los Baños have begun scientific experimentation in cooperation with a small-farmer NGO called Masipag. The International Rice Research Institute has included SRI in one of its research programs to compare it with other management systems, but results have not been reported yet.

In ***Thailand***, the Multiple Cropping Center at Chiang Mai University and the McKean Rehabilitation Center also in Chiang Mai began evaluations of SRI this year, using descriptive materials supplied by CIIFAD. In ***Laos***, the Australian NGO Community Aid Abroad has undertaken trials with farmers, though no results have been reported thus far.

The International Institute for Rural Reconstruction (IIRR) based in the Philippines (a partner with CIIFAD in the Conservation Farming in Tropical Uplands consortium) has worked with the Metta Development Foundation to introduce SRI in its

[4] Yang Saing Koma, "Farmer Experimentation in System of Rice Intensification (SRI): Results of Wet Season 2000," Centre d'Etude et de Développement Agriculture Cambogien, Phnom Penh, January 2001.

agricultural program in ***Myanmar***. In its first season, SRI plots were planted a month too late for good results, so yields were disappointing. But Humayun Kabir, the Metta agricultural advisor, reported that farmers were impressed enough with the growth of SRI plants and the prospect of water saving that they wanted to work further with this method. In 2001, with SRI methods yields were 5.5 t/ha compared with the usual production of 2 t/ha.

Africa

The Gambia

The first results outside of Madagascar in Africa were from ***the Gambia***. There, Mustapha Ceesay, formerly manager of the Ministry of Agriculture's national research station at Sapu and now doing a PhD in agronomy at Cornell, tried these methods during the latter part of 2000 in preparation for thesis research on rice improvement.

The yield range was 5.4 to 8.3 t/ha, depending on variety and spacing, with 30 x 30 cm spacing giving 6.4 to 7.6 t/ha for two different varieties and replicated plots. In June 2001, Ceesay began PhD thesis research in the Gambia including SRI techniques in cooperation with the West African Rice Development Association (WARDA) and with CIIFAD support.

Sierra Leone

In November 2000, Association Tefy Saina and CIIFAD hosted Hilton Lahai from the NGO World Vision in ***Sierra Leone*** for two weeks in Madagascar so that he could learn about SRI directly from Tefy Saina and from farmers practicing the system. In June 2001, prior to the start of the next rice season, farmers from 50 villages volunteered to go through training on SRI that Lahai provided them. How well SRI will perform under the soil and climatic conditions of Sierra Leone will be assessed by the end of the year.

Ivory Coast

In the ***Ivory Coast***, WARDA conducted a series of carefully designed trials during 2000-2001 with the advice and assistance of Willem Stoop, former staff member of WARDA and one of the first agronomists to take an active interest in SRI.[5] Data have not been fully analyzed and reported, but many of the expected effects of SRI practices were observed according to Stoop.

COURTESY MUSTAPHEA CEESAY

Mustapha Cessay cultivates an SRI rice plot at the Gambian Sapu research station with a rotating hoe handweeder.

Ghana

In *Ghana*, there is also interest in evaluating SRI after Uphoff gave a seminar on this methodology at the Ministry of Food and Agriculture's Center for Irrigation Development while there in January 2001 for CIIFAD's Ghana program. Our World Vision partners there are trying to get field trials started.

Mozambique

There have also been contacts with several NGOs in ***Mozambique*** expressing interest in SRI, but no activities have begun on the ground. One of these NGOs has invited our Madagascar partners to send someone with expertise on SRI to participate in a Catholic Relief Services agricultural training program.

[5] A paper entitled "Research Issues Raised for the Agricultural Sciences by the System of Rice Intensification (SRI) from Madagascar: Opportunities for Improving Farming Systems Research for Resource-Limited Farmers," by Stoop, Uphoff, and Amir Kassam, former deputy director-general of WARDA, will appear early in 2002 in *Agricultural Systems*.

Latin America

The strongest interest has come from ***Cuba***, where the *Instituto de Investigaciones del Arroz* is preparing to evaluate SRI methods. This country has had to reduce its dependence on agrochemicals since the Soviet Union could no longer provide petroleum on favorable terms. Cuban farmers have started using organic inputs more systematically.

A manual on SIA, the Spanish acronym for SRI, has been prepared in Spanish language by Rena Perez, a Cornell alumna who has been our liaison in Cuba for evaluating these methods. She is a consultant to the Ministry of Sugar, which has more than 160 sugar plantations and refineries. Each is expected to produce enough rice and other food to feed their own staffs and dependents, 400,000 persons in all. The regional manager in Pinar del Rio who personally used SRI methods on 1.5 hectares reported that these gave a yield of 9.56 t/ha compared to his previous yield of 4.46 t/ha. This gives the ministry good reason to be interested in trying SRI.

In July 2001, e-mail communication was begun with Professor Angel Fernandez in the agronomy department at La Molina agricultural university in ***Peru***. He learned about SRI from a Cornell faculty member. Fernandez expects that SRI can contribute substantially to increased food security for tens of thousands of Peruvian smallholders who grow rice but are capital- and water-constrained.

Also in July 2001, Erick Fernandes (Crop and Soil Sciences) introduced SRI to colleagues with whom he is working in EMBRAPA, the national science agency in ***Brazil***. They will conduct evaluations this coming year.

Madagascar

During the past year, various activities have continued in this country where SRI was developed. A grant from the Rockefeller Foundation to our partners there—Association Tefy Saina, the University of Antananarivo, and the government's agricultural research agency, FoFiFa—has permitted them to carry out a variety of evaluation and extension activities during the year.

The FoFiFa research conducted by Bruno Andrianaivo with detailed measurements of SRI practices on 10 farmers' fields around Fianarantsoa

"Isn't that exciting?"

E-mail from Rena Perez, Havana, July 18, 2001:

A friend, José, who works in sustainable agriculture like myself, just returned from the provinces and promptly called me with the following news:

Several months ago, one night while visiting the province of Matanzas, he started talking to a couple of night watchmen at the place where he stayed, one of whom was a farmer during the day. Jose asked if he planted rice. "Of course," was the reply. "How else can I feed my family?" Jose had with him our manual on SIA so discussed the methodology with the group.

This past week, Jose returned to this place, and it just so happened that the same interested night watchman was on duty. What I am writing I just took down by phone:

The farmer followed all the SRI steps except age of transplants because at that moment he had only 25-day seedlings and wanted to use them.

He used a spacing between plants of 35 by 35 cm.

He discovered that at 90 days, he had plants one meter tall with 60 hijos [tillers] per plant.

He obtained from one cordal [400 sq. meters], eleven 5-gallon cans of rice more yield than in the previous year, when he got 21 cans. Since a can holds 25 pounds of rice (paddy), 32 cans produced from this sized area works out to be 9,125 kg per hectare, 46 percent more than last year. Isn't that exciting?

confirmed that 8 t/ha is a reasonable expectation of average yield with SRI measures.

A very ambitious experiment examining the interactions of six factors affecting yield was carried out by Andry Andriankaja, under the supervision of Professor Randriamiharisoa, for his baccalaureate thesis in agronomy at the University of Antananarivo. On farmers' fields at Anjomakely, 17 km south of Antananarivo on the high plateau, with farmers' cooperation, Andry laid out 240 test plots, 2.5 by 2.5 meters; 144 on better loam-clay soil, and 96 on poorer sandy loam soil. (The latter being poorer, the combination of practices that included no fertilizer amendments was not tested with three replications.)

This study paralleled the factorial trials by Jean de Dieu Rajaonarison reported in last year's Annual Report, conducted on the west coast of Madagascar. In Andry's study, *soil quality* was included as a factor instead of rice variety (traditional vs. high-yielding). All of these trials in 2001 were conducted with a traditional variety, known as riz rouge.

The other factors evaluated were: *water management* (with = SRI; without = conventional, meaning that plots were kept continuously flooded); *fertilization* (compost = SRI; NPK fertilizer = conventional, with no fertilization as a control on the loam-clay soil); *age of seedling* (8 days = SRI; 20 days = conventional); *number of plants per hill* (1 = SRI; 3 = conventional); and *spacing* (25 by 25 and 30 by 30 cm; both are actually within the range recommended for SRI).[6]

The strongest effect in trials at Anjomakely was from using young seedlings. *Ceteris paribus*, 8-day old seedlings averaged 6.3 t/ha compared to 3.8 t/ha for 20-day-old seedlings, a 2.5 ton difference. The water management effect was about half as strong, with rice plots having water control yielding 5.75 t/ha and those under continuous flooding yielding 4.35 t/ha, other things being equal. On these soils, yields with compost averaged 5.5 t/ha, compared with 4.5 t/ha with NPK fertilizer.[7] The effect of planting 1 plant per hill vs. 3 plants per hill, ceteris paribus, was three-quarters of a ton (5.43 vs. 4.65 t/ha).

COURTESY NORMAN UPHOFF

Norman Uphoff and Joeli Barison, on left, talking with farmer, second from right, on whose fields near Anjomakely, Andry Andriankaja, center, conducted factorial trials to assess the separate and combined effects of different SRI practices.

During the past year, Joeli Barison (Crop and Soil Sciences) and Oloro McHugh (Environmental and Biological Engineering) undertook with support from CIIFAD and the Landscape Development Interventions (LDI) project of USAID some extensive and detailed research on differences in plant nutrient uptake attributable to SRI practices, and on effects of different water management regimes. They were advised by Erick Fernandes (CSS) and Tammo Steenhuis (BEE), who visited them in the field during October 2000 and January 2001 to advise on research methods and sampling.

Chris Barrett (Applied Economics and Management), who did his PhD thesis on the rice sector in Madagascar 10 years before, also spent some time with them in March 2001 on research design. Their work included on-farm trials at the Beforona experiment station, and interviews and detailed data gathering from 109 farmers who have been using both SRI and conventional practices on their farms

[6] More complete analysis is given in Andry Andriankaja, "Mise en Evidence des Opportunités de Développement de la Riziculture par Adoption du SRI, et Evaluation de la Fixation Biologique de l'Azote," Départment Agriculture, Ecole Supérieur des Sciences Agronomique, Université d'Antananarivo, 2001. Available on request.

[7] On the better clay-loam soils, the yields without any fertilization averaged 4.25 t/ha. If a high-yielding variety had been used instead of a traditional one, the difference would have been less since HYVs have been selected to be responsive to chemical fertilizer.

in four different parts of Madagascar. An economic analysis of the returns to SRI practices, based on a preliminary analysis of their data, is given in the box on the next page.

Dissemination

Given the productivity advantages of SRI—which raises the productivity of land and of labor and of water concurrently—one would expect this methodology to spread very rapidly. In Madagascar, after a decade of activity by Tefy Saina and some other NGOs, about 50,000 farmers are using most if not all of these methods. But there has been less spread than would have been expected, and there is also some disadoption (abandonment), as much as 30 percent in some programs, and even higher in certain villages.

To get a better understanding of why SRI is not widely, quickly or firmly adopted by farmers in Madagascar, CIIFAD and LDI supported research by Christine Moser (Applied Economics and Management), advised by Chris Barrett (AEM) during the summers of 1999 and 2000. Her findings address some difficult questions about the dissemination of SRI (see box below). They point to the need for better credit institutions and access in

Understanding Barriers to Adoption of SRI

In the five Malagasy villages in my study, 25 percent of rice farmers had tried SRI between 1993 and 1999, but 40 percent of these later abandoned or "disadopted" the method. The main goal of my study was to explain the non-adoption and disadoption of SRI in spite of its remarkable yield potential.

Much of what I found is consistent with the findings of most technology adoption studies—educated farmers with relatively higher income levels adopt SRI more frequently and sooner than their less-educated, poorer neighbors. While one might think that income should not be a constraint for adopting a low-external-input method like SRI, income and especially the timing of that income is crucial.

Rice cultivation is the principal activity in most rural households in Madagascar, but many are unable to grow enough food to feed themselves. Most of their cash income comes from selling part of the rice at harvest time. During the rice-growing season, poorer households are short of money and rice so members must work for wages in other farmers' fields to get by until the next harvest.

Because SRI requires 25 to 50 percent more labor, poorer farmers do not have the time to do extra work. Neither do they have the funds to hire labor. When they have to find ways to feed their families on a daily basis, their opportunity costs of investing in SRI are very high. Farmers who have a stable source of income such as from government salary, or who already produce a surplus of rice are better able to afford the investment of labor and get through the hunger season.

While SRI requires few external inputs and offers remarkable yield increases, many poor farmers are still unable to adopt it due to severe seasonal cash constraints. Helping farmers to overcome seasonal liquidity constraints through income diversification, such as vegetable cash crops grown in the off-season, could reduce the severity of the hunger period and eventually enable them to adopt SRI methods. Providing access to credit at reasonable interest rates might also make SRI more adoptable by the poorest.

—Christine Moser, Applied Economics and Management

Economic Analysis of SRI Methods

As part of their research on agronomic and hydrological aspects of SRI this past year, Joeli Barison and Oloro McHugh gathered production data from 109 farmers in four areas around Madagascar, two on the high plateau and two around Lac Alaotra. Farmers were selected because they had been using SRI methods for one to four years and were still growing some rice with conventional methods. This permitted comparisons in which any farmer skill factors and farm differences could be controlled for.

Skill factors were evident in that these farmers averaged 3.4 tons per hectare with conventional methods, more than 50 percent above the national average of 2 t/ha. Even so, their SRI yields averaged 6.4 t/ha, more than three times the national average.

Analysis of agronomic and hydrological differences has not been completed, but some summary economic comparisons can be reported. These show that although SRI methods require more labor per hectare (+ 28%), the returns to labor were twice this much.

	Conventional	SRI	SRI Change
Labor requirement (man-days/ha)	193	247	54 (+28%)
Yield (kg/ha)	3,359	6,365	3,006 (89%)
Cost of labor/ha @ 5000 FMG/day	963,500	1,233,950	+270,450
Revenue in FMG @ 1000 FMG/kg	3,359,000	6,365,000	3,006,000
Net revenue/ha	2,395,500	5,131,050	+114%
Returns to labor (FMG/day)	17,430	25,790	+56%

The additional cost of labor inputs could be paid for by just 270 additional kilograms of rice per hectare if sold at harvest time when rice prices are at their lowest. If rice is sold some months later when the price is 2000 FMG/kg (30 cents), only 135 kg/ha would be needed to cover additional costs. With added production per hectare of 3,000 kg, the cost of added labor is only a fraction of increased yield. These comparisons do not include non-labor production costs, which are few with SRI since it requires no purchased inputs, so the difference reported here in favor of SRI can be even greater.

When farmers are first learning SRI methods, their labor requirements can be 50 percent more than with conventional practices. However, for experienced SRI farmers, labor input can be less than one-quarter more. For those farmers who with skill and experience are able to get even higher yields, returns will be greater.

rural areas so that the poorest households can afford to invest their labor in SRI cultivation with its high potential returns.

It appears that farmers in some other countries, such as Bangladesh and Sri Lanka, who are more accustomed to changing their rice-growing technology may be more receptive to the opportunities that SRI offers. Profitability and factor productivity are driving motivations once subsistence needs have been assured. That SRI can lower costs of production per kilo of rice appears to be a strong attraction for farmers in Sri Lanka.

It is too early to draw any final conclusions about SRI. As this report shows, there is rapidly expanding interest. In another couple of years, there should be more extensive and conclusive knowledge about SRI in terms of its productivity, its profitability, its distributional effects, and its sustainability. In particular, we are starting to focus on soil microbial factors and dynamics as these seem critical for enhancing soil fertility in response to the management practices introduced by SRI.

CIIFAD and its partners in Madagascar, Association Tefy Saina, the University of Antananarivo, and FoFiFa, welcome scientific interest and cooperation in dissemination efforts that will maintain farmers at the center of the process, evaluating and modifying the methods, not just adopting them. As our Cambodian partner, Yang Saing Koma, has written: "SRI is not about developing rice, but about developing farmers to be a good rice farmer. According to our experience, it does not only make farmers independent, but also promotes interdependency among farmers" (e-mail, August 11, 2001).